

# **AQUACULTURE MANAGEMENT BY INTEGRATING SEAWEED WITH SHRIMP**

THE LIBRARY  
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE  
KOCHI - 682 018

Thesis submitted in partial fulfillment  
of the requirements  
for the degree of

**Ph.D. (Mariculture)**

by

**SEEMA.C, M.F.Sc.  
(Ph.D - 179)**



**CENTRAL INSTITUTE OF FISHERIES EDUCATION**

(Deemed University)

*Indian Council of Agricultural Research*

**Versova, Mumbai – 400 061**

**SEPTEMBER 2008**



# केंद्रीय समुद्री मात्स्यिकी अनुसंधान संस्थान

पोस्ट बॉक्स सं 1603, एरणाकुलम, कोचीन- 682018

**CENTRAL MARINE FISHERIES RESEARCH INSTITUTE**

POST BOX No. 1603, ERNAKULAM, COCHIN- 682018

(भारतीय कृषि अनुसंधान परिषद)

(Indian Council of Agricultural Research)

Phone (Off) : 394867/....Ext.  
391407  
Telegram : CADALMIN EKM  
Telex : 0885-6435 MFRI IN  
Fax : 0484-394909  
E-mail : mdcnmfri@md2.vsnl.net

**Dated 8 September, 2008**

## CERTIFICATE

Certified that the thesis entitled "**AQUACULTURE MANAGEMENT BY INTEGRATING SEAWEED WITH SHRIMP**" is a record of independent bonafide research work carried out by **Mrs. Seema. C** (Ph.D – 179) during the period of study from September 2002 to September 2008 under our supervision and guidance for the degree of **Doctor of Philosophy (Mariculture)** and that the thesis has not been previously formed the basis for the award of any degree, diploma, associateship, fellowship or any other similar title.

**Major Advisor/Chairman**

*Jayasankar*

**Reeta Jayasankar**

Principal Scientist  
Mariculture Division

**Advisory Committee**

*K. Krishnakumar*

**P.K. Krishnakumar**  
(Co-Chairman)  
Principal Scientist  
Fishery Environment  
Management Division

*K.S. Shobana*

**K.S. Shobana**  
(Member)  
Senior Scientist  
Physiology Nutrition And  
Pathology Division

*M. K. J. Joseph*  
12/2/08

*D. Prema*

**D. Prema**  
(Member)  
Senior Scientist  
Fishery Environment  
Management Division

*Somy Kuriakose*

**Somy Kuriakose**  
(Member)  
Senior Scientist  
Fishery Resource  
Assessment Division

# DECLARATION

I hereby declare that the thesis entitled “ **AQUACULTURE MANAGEMENT BY INTEGRATING SEAWEED WITH SHRIMP**” is an authentic record of the work done by me and that no part thereof has been presented for the award of any degree, diploma, associateship, fellowship or any other similar title.

26 September 2008  
Cochin

  
(Seema. C)  
Ph.D Student  
Central Marine Fisheries  
Research Institute

# ACKNOWLEDGEMENTS

# ACKNOWLEDGEMENTS

I express my deep sense of gratitude to my major advisor **Dr. (Mrs.) Reeta Jayasankar**, Principal Scientist, CMFRI, Cochin for her effective guidance, timely help, unstinted support and immense encouragement extended to me during the whole period of work and also in the preparation of manuscript. My sincere thanks to **Dr P.K. Krishnakumar**, Principal Scientist, **Dr. D. Prema**, Senior Scientist, **Dr. K.S. Sobhana**, Senior Scientist and **Dr. Somy Kuriakose**, members of the advisory committee for their kind support, valuable suggestion and help extended to me during the tenure of this work.

I am extremely grateful to **Prof. (Dr.) Mohan Joseph Modayil**, Director, CMFRI, Cochin for providing me all the facilities to carry out the research work. I take this opportunity to thank **Dr. R. Paul Raj**, Principal Scientist, **Dr. P.C. Thomas**, Principal Scientist, **Dr. M. Rajagopalan**, Principal Scientist, **Dr. A. Laxminarayana**, Principal Scientist and **Dr. Sunil Kumar Mohammed**, Principal Scientist, for allowing me to access all the facilities in their division.

My sincere thanks are due to **Dr. N. Kaliaperumal**, Principal Scientist, **Dr. K. Gopakumar**, Principal Scientist, **Dr. Bindu Sulochanan**, Scientist, **Mr. J.R. Ramalingam**, Technical Officer, **Mr. Chidambaram**, Librarian and other staff members of Mandapam Regional centre of CMFRI for their kind cooperation and helps during the research work.

I extend my sincere thanks to **Dr. P. Jayasankar**, **Dr. V. Kripa**, **Dr. C. Ramachandran** and **Dr. Feemena Hassan** for all the encouragement and support.

I whole heartedly thank **Mr. A. Nandakumar**, **Mr. L.R. Khambadkar**, **Smt. A. Kanagam**, **Smt. K.K. Valsala**, **Smt. K.S. Leelabhai**, **Smt. Jenny Sharma** and **Smt. Pennamma Joseph** for helping me in the laboratory analysis of samples.

My thanks are due to **Mr. Chandrasekharan** and staff of PGPM, **Mr. Edwin Joseph**, Librarian and Library staff for all the help provided to me during the course of study.

I express my deep sense of gratitude to **Dr. Martin Thompson**, OIC, Krishi Vigyan Kendra, Narakkal and **Mr. Vjayan**, Arun Aqua for rendering farm for the research work.

I would like to express my deep felt thanks to **Dr. M.M. Jose** and **Prof. (Dr.) Susheela Jose** of Fisheries Station, Kerala Agricultural University, Puduveypu for their valuable suggestions and support.

I am very much grateful to my friends **Divya, Sandhya, Reghu, Latha, Neetha, Sangeetha** and **Anand** for all their encouragement and helps. My special thanks are due to my juniors **Asha, Vidya, Hena, Sajitha** and **Vinoj** for their timely help.

I am indebted to my **Husband** for his cooperation, valuable suggestions, timely help, moral support, encouragements and good wishes which helped me to complete the research work successfully.

Words cannot express my deep felt gratitude to **Amma, sisters-in-law** and **family members** for the moral support and encouragements extended to me.

It is my privilege to thank my **grand parents, parents** and **family members** for their cooperation and encouragement throughout the period of my research work.

I hereby acknowledge **Indian Council of Agricultural Research**, New Delhi for awarding me Senior Research Fellowship during the tenure of study period at CMFRI.

Let me thank **God Almighty** for giving me such an opportunity in life

## सारांश

जलजीव पालन विश्व में तेज़ बढ़ने वाला खाद्योत्पादन का मुख्य क्षेत्र है। परन्तु तटीय प्रदूषण की वजह से यह क्षेत्र अत्यधिक छानबीन और समालोचना के विषय बन गए हैं। जैव पदार्थों, नाइट्रोजन यौगिकों, फोस्फोरस और अन्य पोषक घटकों से भरा हुआ गहन पालन व्यवस्था के बहिस्त्राव जलजीव पालन के लिए अनुपयुक्त होता है और इस से प्राकृतिक जल पर अनावश्यक सुपोषण भी होता है। स्थूल शैवाल पानी के विषाक्त अपशिष्टों को उचित और पालनयोग्य स्तर तक नियंत्रित रखने और पानी की गुणवत्ता बढ़ाने में महत्वपूर्ण भूमिका निभाते हैं। जलजीव पालन व्यवस्था में समुद्री शैwalों को एकीकृत करके प्रभावकारी प्रबंधन किया जा सकता है। समुद्री शैवाल को जलजीव पालन प्रणाली में चिंगट के साथ सही मात्रा में एकत्रित करके अथवा चिंगट के बहिस्त्राव को दूसरे तालाब में शैवाल द्वारा जल शोधन करके पुनः व्यवहार किया जा सकता है। वर्तमान अध्ययन में, भारत के दक्षिण पश्चिम तट के ज्वार से भरी हुई पश्चजल व्यवस्था में और दक्षिण पूर्व तट के पम्प द्वारा भरी हुई समुद्र जल की पालन व्यवस्था में चिंगट के साथ एकीकृत पालन करने के लिए अनुकूल समुद्री शैवाल जाति को पहचानने का प्रयास किया गया है। नियंत्रित तालाबों की तुलना में उपचार तालाबों में समुद्री शैwalों द्वारा अमोणिया, नाइट्रेट, नाइट्रेट जैसे नाइट्रोजीनस यौगिकों और कुल नाइट्रोजन का निष्कासन क्रमशः 65-82%, 34-53%, 28-77% और 53-60% देखा गया। पश्चजल के तालाबों में चिंगटों के साथ एकीकृत पालन करने के लिए *ग्रासिलेरिया वेरुकोसा* अत्यंत अनुयोज्य है और मानसून अवधि के दौरान भारत के दक्षिण पश्चिम तट में मानसूनोत्तर अवधि अत्यधिक अनुकूलतम देखी गयी क्योंकि इस समय समुद्री शैवाल और चिंगट की वृद्धि दर ज्यादा पायी गयी है। भारत के दक्षिण पश्चिम तट में विषाक्त अपशिष्टों का संचयन कम होने पर भी जलजीव पालन व्यवस्था की वृद्धि दर तुलनात्मक ढंग से कम पाया गया है। अनुकूलतम संभरण सघनता में *जी. वेरुकोसा* के साथ *एन्टरोमोर्फा इन्टेस्टानालिस* का एकीकृत पालन करने पर बीजाणु खनिजीभवन द्वारा या समुद्री शैwalों के सीधा उपयोग द्वारा अधिक नाइट्रोजीनस अपशिष्टों की घटौती होने के कारण चिंगटों पर कम दबाव पड़ता है। नदीमुखों में बढ़ने वाली जाति होने के नाते *जी. वेरुकोसा* लवणता के परास को बेहतर ढंग से सहन कर सकती है और अगरोफाइट होने की वजह से खनिजीभवन के लिए उपयोगी धरातल द्वारा बीजाणुओं को बढ़ने के लिए आश्रय भी देती है। वर्तमान संदर्भ में, परीक्षण के पहले वर्ष में *जी. वेरुकोसा* की अत्यधिक वृद्धि से लगभग 880 कि.ग्रा. का फसल संग्रहण किया गया। इसके अतिरिक्त तालाब में वर्षों से घली आ रही जलजीव कृषि के कारण भारी मात्रा में उपलब्ध न्यूट्रिएन्ट को शोषित करने में सक्षम पाया गया। समुद्री शैवाल तालाब में पादपप्लवकों की अनावश्यक बढ़ती को रोकने में सहायक होता है। यह भी देखा गया है कि तालाब में शैवाल बढ़ने से चिंगटों में होने वाले रोगों में कमी पायी गयी है।

# ABSTRACT

Aquaculture is the fastest growing food production sector in the world and has come under increasing scrutiny and criticism because of coastal pollution. Effluents from intensive farming contain much organic matter, nitrogen compounds, phosphorus and other nutrients, makes the water unfit for aquaculture and lead to eutrophication. Macroalgae plays a vital role in controlling toxic wastes to reasonable and cultivable limits and also improves water quality. Aquaculture management can be done effectively by integrating seaweeds into aquaculture systems. This method can be done either by stocking seaweeds along with shrimp in optimum stocking density or by recycling the water through a pond supplemented with seaweeds. In the present study an attempt has been made to find out the species of seaweed suitable for integrated farming with shrimp in brackish water tide-fed system on southwest coast and sea water in pump-fed system on southeast coast of India. The removal of nitrogenous compounds such as ammonia, nitrate, nitrite and total nitrogen was found to be 65 to 82%, 34 to 53%, 28 to 77% and 53 to 60% respectively by seaweeds in the treatment ponds when compared to the control ponds. The species of *Gracilaria verrucosa*, proved to be an ideal seaweed for integrated farming with shrimp in the brackishwater ponds and post monsoon period is the most favourable period for integrated farming as the growth performance of seaweed and shrimp were found to be more than the monsoon period in the tide-fed system of southeast coast of India. Eventhough the accumulation of toxic waste was less compared to southwest coast, the growth rate was comparatively lower in sea water system of southeast coast of India. *G. verrucosa* integrated with *Enteromorpha intestinalis* in optimum stocking density can reduce stress on shrimp by utilizing excess nitrogenous wastes either through bacterial mineralization or direct use by seaweeds. In the present context, luxuriant growth of *G. verrucosa* in the first year of experiment leading to harvest of 880kg was due to the heavy amount of nutrient loaded in the pond for age long aquaculture activity, which enabled the proliferation of algal growth and maximum removal of nitrogenous load from the system. It was also observed that growth of alga in the pond was able to minimize the disease problems in shrimp.



# CONTENTS

<b>1</b>	<b>INTRODUCTION</b>	<b>1</b>
<b>2</b>	<b>REVIEW OF LITERATURE</b>	<b>4</b>
2.1	Water quality parameters	4
2.2	Soil quality parameters	8
2.3	Bioremediation	9
2.4	Seaweeds and water quality	11
2.5	Integrated framing	13
2.6	Heavy metals and algae	19
<b>3</b>	<b>MATERIALS AND METHODS</b>	<b>23</b>
3.1	Selection and preparation of culture site	23
3.2	Collection of seaweeds and shrimp for experiment	27
3.3	Stocking	27
3.4	Sampling procedure	30
3.4.1	Frequency of sampling	30
3.4.2	Monitoring of water quality parameters	30
3.4.2.1	Water pH	30
3.4.2.2	Temperature	30
3.4.2.3	Salinity	30
3.4.2.4	Dissolved Oxygen	31
3.4.2.5	Biochemical Oxygen Demand	31
3.4.2.6	Nitrate	31
3.4.2.7	Nitrite	31
3.4.2.8	Ammonia	31
3.4.2.9	Phosphate	32
3.4.2.10	Silicate	32
3.4.2.11	Heavy metals	32
3.4.3	Monitoring of soil quality parameters	32
3.4.3.1	Soil pH	32
3.4.3.2	Organic Carbon	32

3.4.4	Shrimp growth	33
3.4.5	Seaweeds	33
3.4.5.1	Growth estimation	33
3.4.5.2	Estimation of photosynthetic pigments	33
3.5	Statistical Analysis	34
<b>4</b>	<b>RESULTS</b>	<b>35</b>
4.1	Tide-fed system on Southwest coast of India	35
4.1.1	Experimental farming of seaweed and shrimp during monsoon.	35
4.1.1.1	Environmental Parameters	35
4.1.1.2	Water quality parameters	37
4.1.1.3	Soil quality parameters	44
4.1.1.4	Pigment content of <i>Gracilaria verrucosa</i>	47
4.1.2	Experimental farming of seaweed and shrimp during post monsoon season	53
4.1.2.1	Environmental parameters	53
4.1.2.2	Water quality parameters	53
4.1.2.3	Soil quality parameters	63
4.1.2.4	Pigment content of <i>Gracilaria verrucosa</i>	63
4.2	Pump-fed system on Southeast coast of India	69
4.2.1	Environmental parameters	69
4.2.2	Water quality parameters	72
4.2.3	Soil quality parameters	77
4.2.4	Pigment concentration of seaweeds	80
<b>5</b>	<b>DISCUSSION</b>	<b>87</b>
	<b>SUMMARY</b>	<b>103</b>
	<b>REFERENCES</b>	<b>106</b>

## LIST OF TABLES

<b>Table 1</b>	Analysis of variance for water pH and salinity during monsoon period	36
<b>Table 2</b>	Analysis of variance for Dissolved oxygen and Biochemical oxygen Demand during monsoon period	38
<b>Table 3</b>	Analysis of variance for nitrate and nitrite during monsoon period	40
<b>Table 4</b>	Analysis of variance for ammonia and total nitrogen during monsoon period	41
<b>Table 5</b>	Analysis of variance for phosphate and silicate during monsoon period	43
<b>Table 6</b>	Analysis of variance for heavy metals during monsoon period	45
<b>Table 7</b>	Analysis of variance for soil pH and organic carbon during monsoon period	46
<b>Table 8</b>	Growth assessment of shrimp in the tide-fed culture system of shrimp and seaweed during monsoon period	49
<b>Table 9</b>	Correlation of parameters in the tide-fed culture system of shrimp and seaweed during monsoon period	50
<b>Table 10</b>	Correlation of environmental parameters with shrimp growth in the tide-fed culture system during monsoon period	51

<b>Table 11</b>	Correlation of water quality parameters with shrimp growth in the tide-fed culture system during monsoon period	52
<b>Table 12</b>	Environmental parameters in the culture system of shrimp and seaweed during post monsoon period	54
<b>Table 13</b>	Analysis of variance for Dissolved oxygen and Biochemical oxygen demand during post monsoon period	56
<b>Table 14</b>	Analysis of variance for nitrate and nitrite during post monsoon period	57
<b>Table 15</b>	Analysis of variance for ammonia and total nitrogen during post monsoon period	59
<b>Table 16</b>	Analysis of variance for phosphate and silicate during post monsoon period	61
<b>Table 17</b>	Analysis of variance for heavy metals during post monsoon period	62
<b>Table 18</b>	Analysis of variance for soil pH and organic carbon during post monsoon period	64
<b>Table 19</b>	Growth assessment of shrimp in the tide-fed culture system of shrimp and seaweed during post monsoon period	65
<b>Table 20</b>	Correlation of parameters in the tide-fed culture system of shrimp and seaweed during post monsoon period	66
<b>Table 21</b>	Correlation of environmental parameters with shrimp growth in the tide-fed culture system during post monsoon period	67

<b>Table 22</b>	Correlation of water quality parameters with shrimp growth in the tide-fed culture system during post monsoon period	68
<b>Table 23</b>	Analysis of variance for water pH in pump-fed system	70
<b>Table 24</b>	Analysis of variance for dissolved oxygen in pump-fed system	71
<b>Table 25</b>	Analysis of variance for nitrate and nitrite during post monsoon	73
<b>Table 26</b>	Analysis of variance for ammonia and total nitrogen in pump-fed system	74
<b>Table 27</b>	Analysis of variance for phosphate and silicate during post monsoon	76
<b>Table 28</b>	Analysis of variance for heavy metals in pump-fed system	78
<b>Table 29</b>	Analysis of variance for soil pH and organic carbon in pump-fed system	79
<b>Table 30</b>	Growth assessment of shrimp in the pump-fed culture system of shrimp and seaweed	83
<b>Table 31</b>	Correlation of parameters in the pump-fed culture system of shrimp and seaweed	84
<b>Table 32</b>	Correlation of environmental parameters with shrimp growth in the pump-fed culture system	85
<b>Table 33</b>	Correlation of water quality parameters with shrimp growth in the pump-fed culture system	86

## LIST OF FIGURES

<b>Fig. 1</b>	Location map of study site of Narakkal	24
<b>Fig. 2</b>	Location map of study site of Ramanthapuram	25
<b>Fig. 3</b>	Environmental parameters in the culture system of shrimp and seaweed during monsoon period	36
<b>Fig. 4</b>	Dissolved Oxygen and Biochemical Oxygen Demand in the culture system of shrimp and seaweed during the monsoon period	38
<b>Fig. 5</b>	Nitrate and Nitrite concentration in the culture system of shrimp and seaweed during monsoon period	40
<b>Fig. 6</b>	Ammonia and Total Nitrogen concentration in the culture system of shrimp and seaweed during monsoon period	41
<b>Fig. 7</b>	Phosphate and Silicate concentration in the culture system of shrimp and seaweed during monsoon period	43
<b>Fig. 8</b>	Heavy metal concentration in the culture system of shrimp and seaweed during monsoon period	45
<b>Fig. 9</b>	Soil pH and Organic Carbon concentration in the culture system of shrimp and seaweed during monsoon period	46
<b>Fig. 10</b>	Pigment concentration of <i>Gracilaria verrucosa</i> in the culture system of shrimp and seaweed during monsoon period	48
<b>Fig. 11</b>	Environmental parameters in the culture system of shrimp and seaweed during post monsoon period	54

<b>Fig. 12</b>	Dissolved oxygen and biochemical oxygen demand in the culture system of shrimp and seaweed during post monsoon period	56
<b>Fig. 13</b>	Nitrate and nitrite concentration in the culture system of shrimp and seaweed during post monsoon period	57
<b>Fig. 14</b>	Ammonia and total nitrogen concentration in the culture system of shrimp and seaweed during post monsoon period	59
<b>Fig. 15</b>	Phosphate and silicate concentration in the culture system of shrimp and seaweed during post monsoon period	61
<b>Fig. 16</b>	Heavy metal concentration in the culture system of shrimp and seaweed during post monsoon period	62
<b>Fig. 17</b>	Soil pH and Organic Carbon in the culture system of shrimp and seaweed during post monsoon period	64
<b>Fig. 18</b>	Pigment concentration of <i>Gracilaria verrucosa</i> in the culture system of shrimp and seaweed during post monsoon period	65
<b>Fig. 19</b>	Environmental parameters in the pump-fed culture system of shrimp and seaweed	70
<b>Fig. 20</b>	Dissolved oxygen concentration in the pump-fed culture system of shrimp and seaweed	71
<b>Fig. 21</b>	Nitrate and Nitrite concentration in the pump-fed culture system of shrimp and seaweed	73
<b>Fig. 22</b>	Ammonia and total nitrogen concentration in the pump-fed culture system of shrimp and seaweed	74

<b>Fig. 23</b>	Phosphate and silicate concentration in the pump-fed culture system of shrimp and seaweed	76
<b>Fig. 24</b>	Heavy metals in the pump-fed culture system of shrimp and seaweed	78
<b>Fig. 25</b>	Soil pH and organic carbon content in the pump-fed culture system of shrimp and seaweed	79
<b>Fig. 26</b>	Pigment concentration of <i>Gracilaria corticata</i> in the pump-fed culture system of shrimp and seaweed	81
<b>Fig. 27</b>	Pigment concentration of <i>Kappaphycus alvarezii</i> in the pump-fed culture system of shrimp and seaweed	82



# LIST OF PLATES

<b>Plate 1</b>	Shrimp culture ponds for the tide-fed system at Narakkal	26
<b>Plate 2</b>	Shrimp culture ponds for the pump-fed system at Ramanathapuram	26
<b>Plate 3</b>	Species of shrimp used for the integrated farming with seaweeds	28
<b>Plate 4</b>	Species of seaweed used for the integrated farming with shrimp on southwest coast of India	28
<b>Plate 5</b>	Species of seaweeds used for the integrated farming with shrimp on southeast coast of India	29

# INTRODUCTION

Full Text Not Available